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SUPPLEMENT TO A REPORT BY THE
Comptroller General
OF THE UNITED STATES

Issues Concerning The Department Of Energy's Justification For Building The Gas Centrifuge Enrichment Plant

This supplement contains GAO's analysis of and response to the Department of Energy's (DOE's) comments on GAO's May 25, 1982, report on the same subject. In that report, GAO raised a number of questions about DOE's justification for building a gas centrifuge uranium enrichment plant at Portsmouth, Ohio, at a cost of \$7 billion (fiscal year 1983 dollars).

The thrust of DOE's comments on GAO's report is that DOE must build the gas centrifuge plant or it will price itself out of the uranium enrichment market. Upon careful analysis of DOE's comments, GAO continues to believe the issues raised in its May 25 report are appropriate for consideration by the Congress.

After DOE commented on GAO's report, two events occurred which also bear on the issues discussed in GAO's report and DOE's comments. Specifically, DOE accelerated its timetables for developing two advanced enrichment technologies. This supplement, therefore, also briefly discusses DOE's decisions to accelerate these development programs and the technical basis for them.



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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D.C. 20548

B-207463

The Honorable Richard L. Ottinger
Chairman, Subcommittee on Energy
Conservation and Power
Committee on Energy and Commerce
House of Representatives

Dear Mr. Chairman:

This supplement contains the Department of Energy's (DOE's) comments on our report (GAO/EMD-82-88, May 25, 1982), our evaluation of those comments, and a brief discussion of events related to DOE's development of advanced uranium enrichment technologies which have occurred since DOE commented on our issued report. The supplement should be considered as an integral part of the issued report.

It is our normal policy to obtain DOE comments on drafts of reports concerning DOE activities. In this case, however, comments were not obtained so that the report could be issued in time for use during the appropriation process. This supplement is being issued to provide you and other interested committees and Members of Congress with DOE comments received after the report was issued and our evaluation of them.

Uranium enrichment is a process which prepares uranium as a nuclear reactor fuel. Since 1969 DOE and its predecessor agencies have been enriching uranium owned by domestic and foreign utilities. DOE's existing enrichment plants were built in the 1940's and 1950's. The plants use an electricity-intensive technology called gaseous diffusion. DOE is now building a new enrichment plant at Portsmouth, Ohio, using a technology called gas centrifuge. This technology is capital-intensive--it requires tens of thousands of centrifuge machines--but uses only about 5 percent of the electricity required by the gaseous diffusion plants.

In our issued report, we said that building the gas centrifuge plant is not justified at current projections of demand for DOE's enrichment services. We stated that the project is only economical if events cause a sudden increase in the demand for

nuclear power or DOE's efforts to develop another more advanced enrichment technology--called advanced isotope separation--fail. We concluded that if DOE does not build the centrifuge plant and either of these events occur DOE would still have sufficient time to build new enrichment capacity.

DOE's basic position is that it must build the gas centrifuge plant or the United States will price itself out of the enrichment market. In its comments, DOE points out areas of agreement and disagreement with our report.

There were two key areas where DOE's comments generally agreed with our report. First, DOE agreed that expected future demand for its enrichment services had declined from its earlier estimates. DOE added that its latest demand forecast is close to our estimate of 217 gigawatts-electric¹ by the year 2000. This is 49 gigawatts lower than DOE's official estimate of 266 gigawatts when we issued our report. Thus, DOE does not anticipate a sudden increase in the demand for nuclear power. Second, DOE acknowledged that its 1980 uranium enrichment strategy study reached the same conclusion we reached in our economic analysis: that DOE could provide enrichment services at the lowest cost by terminating the gas centrifuge plant and replacing existing gaseous diffusion capacity in the mid-1990's with an enrichment facility using the advanced isotope separation enrichment technology. DOE pointed out, however, that this conclusion presumes successful development of the advanced technology. In this regard, DOE said that the advanced technology must reach a higher stage of development before it can be counted on for production planning.

DOE disagreed with our report in three key areas. DOE said that our economic analysis was incomplete, inaccurate, and relied too heavily on a DOE economic model to the exclusion of other economic analyses. DOE added that other analyses it has made support its position that completing the gas centrifuge plant will lower enrichment costs. DOE also said that our analysis of its competitive market position suffered from an outdated perception of the world market. DOE believes that we did not place enough importance on what it considers to be improvements to its competitive position which have been brought about during the current administration. In this regard, DOE said price is now the principal factor affecting potential customers' enrichment services supply decisions. Finally, DOE disagreed with several aspects of our analysis of the budgetary impacts of

¹A gigawatt-electric is 1 million kilowatts of electricity. Most modern nuclear powerplants are capable of producing about 1 gigawatt of electricity.

completing, partially completing, and terminating the gas centrifuge plant. In particular, DOE pointed out that expenditures for its enrichment program--including construction of the gas centrifuge plant--do not require net appropriations and do not contribute to the national debt because annual revenues from the sale of enrichment services exceed total annual outlays for the enrichment program.

Based on our evaluation of DOE's comments, we see no need to change our basic conclusion that building the gas centrifuge plant is not justified at current expected enrichment services demand levels. First, our economic analysis was based on the economic model DOE used to prepare its October 1980 Uranium Enrichment Strategy Study. This economic model was better suited than other available economic models because it covers a longer period--31 years--for evaluating long-range alternatives. By contrast, the other economic analyses on which DOE relies cover only a 20-year period, including only 7 to 8 years of use of the advanced isotope separation technology.

Second, while the current administration's policies may have improved DOE's competitive position in the enrichment market, there is no guarantee that future administrations will pursue similar policies. Furthermore, while price may now be important in customers' enrichment services supply decisions, in the long run factors such as U.S. foreign policy, legal requirements limiting DOE's price flexibility, and customers' desires for enrichment services supply diversification will also affect DOE's ability to attract and retain enrichment customers.

Finally, while annual revenues from the sale of DOE enrichment services may exceed total annual outlays for the enrichment program, the enrichment program will nevertheless contribute to annual budget deficits as long as DOE uses the revenues to finance projects such as gas centrifuge plant construction.

If DOE was not building the gas centrifuge plant, annual revenues in excess of enrichment program costs could be made available to the Government for other uses. The reason for this is that a portion of DOE's enrichment services revenues represent recovery of costs to the Government--such as imputed interest on the Government's investment in the uranium enrichment program--for which DOE does not require appropriations or incur budgetary outlays. Thus, if DOE was not using revenues derived from recovery of imputed interest costs to build the gas centrifuge plant, those revenues could be used to reduce annual Federal budget deficits and, therefore, reduce the contribution of an annual budget deficit to the growing national debt.

In pointing out the areas of agreement and disagreement with our report, DOE has also raised the central issue which should be considered in deciding whether DOE should complete the gas centrifuge plant as planned. That issue is the risk inherent in canceling the gas centrifuge plant in favor of developing and deploying the advanced isotope separation enrichment technology in the mid-1990's. As stated on the previous page, DOE acknowledged that its 1980 Strategy Study indicated that in the long run DOE could provide enrichment services at the lowest cost by deploying the advanced isotope separation technology in the mid-1990's in lieu of building the gas centrifuge plant. However, DOE also believes it must build the gas centrifuge plant because it cannot yet count on the advanced isotope separation technology for production planning.

Since DOE commented on our report, two events have occurred which relate to the issue of risks associated with not building the gas centrifuge plant and the budgetary costs of avoiding those risks. First, DOE has modified and accelerated its advanced isotope separation technology development program. DOE now expects to be able to decide whether it can use this technology in a production-scale enrichment plant by 1987--3 years earlier than DOE planned when it commented on our report. Second, DOE has also accelerated its program for developing gas centrifuge machines which would be even more efficient than the advanced machines DOE now plans to install in the last six buildings of the eight-building gas centrifuge plant. If this development program is successful, DOE now believes that it may be possible to install the more advanced machines in the gas centrifuge plant as early as 1991. At the time DOE commented on our issued report, it did not expect to install these machines in the plant until sometime after 1994.

We have not evaluated the basis for DOE's current position regarding these two advanced enrichment technology programs, nor have we evaluated the ramifications that the accelerated development schedules might have for DOE's current plans to build the gas centrifuge plant. For example, the accelerated schedule for the advanced isotope separation technology appears to reduce the risks of not building the gas centrifuge plant. On the other hand, the accelerated development program for advanced gas centrifuge machines, coupled with the Government's existing investment in the gas centrifuge plant, may argue for completing the plant on DOE's current schedule or some modified schedule. Finally, since the two advanced technologies appear to be in competition, another plausible ramification of DOE's decision to accelerate the two development programs might be to stretch out or defer construction of the gas centrifuge plant until DOE demonstrates the two advanced technologies.

In summary, based on our evaluation of DOE's comments, we continue to believe that building the gas centrifuge plant is not justified unless events cause a sudden increase in the demand for nuclear power or DOE's efforts to develop the advanced isotope separation enrichment technology fail. DOE, on the other hand, believes it needs to build the gas centrifuge plant because it believes building the plant will enhance its competitive position in the enrichment market and provide a hedge against unanticipated difficulty in developing the potentially even more competitive advanced isotope separation technology.

Thus, we believe the central issue for congressional decisionmakers boils down to the risk that DOE will not succeed in its current efforts to develop the potentially more price-competitive advanced isotope separation technology, weighed against the short-term budgetary cost of avoiding this risk. We believe that decisionmakers should be aware of the following considerations in evaluating this issue:

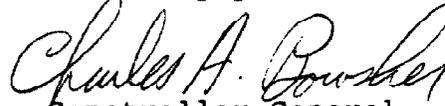
- The ramifications of DOE's recent decisions to accelerate development of the advanced isotope separation and advanced gas centrifuge machine technologies. Clearly, DOE's decisions to accelerate these development programs indicates that, in DOE's judgment, both programs are proceeding better than had been expected.
- The cost of avoiding the risk that DOE's advanced isotope separation technology might fail. This cost is the \$5.5 billion (fiscal year 1983 dollars) in Federal funds which DOE estimates will be required in fiscal years 1983 through 1994 to complete the gas centrifuge plant. DOE expects that these funds will be provided out of enrichment services revenues. As discussed above, however, if DOE was not building the gas centrifuge plant, revenues from the sale of enrichment services in excess of DOE's budgetary outlays to provide those services could be made available for other Government uses.
- Regardless of the enrichment strategy pursued by DOE, it is uncertain what the impact of the strategy would be in DOE's ability to attract new customers. For example, in its comments DOE estimated that the 30-year lifetime value of the 10 potential new foreign enrichment services contracts it has identified, plus contracts it signed with Egypt in May 1982, is about \$4.5 billion--about \$1 billion less than the cost of completing the gas centrifuge plant. DOE did not identify any potential new domestic sales of enrichment services. It remains to be seen, however, whether DOE will obtain any or all of the potential new foreign business.

Chapter 1 of this supplement contains the digest of our original report. Chapter 2 contains our detailed evaluation of DOE's comments relating to the central issue of the risks associated with not building the gas centrifuge plant and the cost of avoiding those risks. It also discusses in more detail the events related to DOE's development of advanced enrichment technologies which have occurred since DOE commented on our report. Chapter 3 contains our detailed evaluation of DOE's comments on our report which do not directly relate to the risk issue. The full text of DOE's comments, which consist of a letter and a detailed enclosure, are contained in appendix I.

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Copies of this supplement are also being sent to cognizant committee and subcommittee chairmen; interested Members of Congress; the Secretary of Energy; and the Director, Office of Management and Budget.

Sincerely yours,


Comptroller General
of the United States

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ABBREVIATIONS

AIS	advanced isotope separation enrichment technology
DOE	Department of Energy
EDIC	Department of Energy economic model
EIA	Energy Information Administration
GAO	General Accounting Office
GCEP	gas centrifuge enrichment plant
GDP	gaseous diffusion enrichment plant
GNP	Gross National Product
SWU	separative work unit

CHAPTER 1

COMPTROLLER GENERAL'S
REPORT TO THE SUBCOMMITTEE
ON ENERGY CONSERVATION AND
POWER, COMMITTEE ON ENERGY
AND COMMERCE, HOUSE OF
REPRESENTATIVES

ISSUES CONCERNING THE DEPARTMENT
OF ENERGY'S JUSTIFICATION FOR
BUILDING THE GAS CENTRIFUGE
ENRICHMENT PLANT

D I G E S T

The Department of Energy (DOE) is building a gas centrifuge uranium enrichment plant at Portsmouth, Ohio. By the end of this fiscal year, DOE will have spent about \$1.2 billion on the project. DOE expects to complete it in 1994 at a total cost of \$7 billion (fiscal year 1983 dollars).

At present, DOE enriches uranium for its domestic and foreign customers at three enrichment plants. These plants use a dependable but electric power-intensive technology known as gaseous diffusion. Although the three plants were built in the 1940s and 1950s, DOE is nearing completion of a 10-year, \$1.5 billion program to improve their efficiency and increase their commercial production capacity by about 60 percent. When completed, the plants will be able to provide the enrichment services required for nuclear power reactors to produce up to 240 gigawatts-electric 1/-- or about 240 nuclear power plants--plus expected Government requirements.

DOE has also developed a more energy efficient technology, called gas centrifuge, which can be built in increments to better match supply with demand and which DOE plans to use in the enrichment plant now under construction. Because it is more energy efficient, the operating costs of a centrifuge plant are expected to be much less than operating costs of gaseous diffusion plants. Conversely, capital and maintenance costs are expected to be higher. Nevertheless, when the plant is completed in 1994, DOE expects that it will provide enrichment

1/A gigawatt-electric is one million kilowatts of electricity. Most modern nuclear power plants are capable of producing about one gigawatt of electricity.

services at less cost than the gaseous diffusion plants. Therefore, at that time DOE plans to cut back on its gaseous diffusion plant operations.

In addition, DOE is in the early stage of developing an advanced isotope separation enrichment technology. If successful, DOE believes it can reduce the costs of enriching uranium substantially below the costs of either of the other two enrichment technologies. Although there are still some uncertainties--the technology has never been commercially demonstrated--DOE believes this new technology could be developed and a production facility could be available as early as the mid-1990s.

When the Congress authorized construction of additional enrichment capacity in 1975, demand for U.S. enrichment services was expected to exceed the increased capacity of the improved gaseous diffusion plants by the early 1980s. This demand never materialized, however, because of two events. First, beginning in the mid-1970s, numerous nuclear power plants were canceled and deferred in the United States and elsewhere. Second, new foreign enrichment services suppliers emerged and obtained major shares of the foreign enrichment services market. Thus, since 1975 the United States has changed from a near monopoly supplier of enrichment services to an expanding nuclear power industry, to one of several suppliers to an industry with diminished growth expectations.

In a November 1980 report GAO noted these changed circumstances and recommended that the Congress consider not appropriating additional funds for construction of uncommitted increments of the gas centrifuge capacity until DOE developed and presented sufficient documentation to demonstrate that the additional capacity was needed to meet demand, to further U.S. non-proliferation objectives, or was justified on an economic basis. ^{1/} At

^{1/}"Evaluation of Selected Features of U.S. Nuclear Non-Proliferation Law and Policy," EMD-81-9, Nov. 18, 1980.

about the same time, DOE began to justify the gas centrifuge plant on the basis of long-range economic, nuclear non-proliferation, and balance-of-trade benefits in addition to meeting expected demand.

At the request of the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, GAO evaluated DOE's current justification for building the new gas centrifuge enrichment plant by answering three basic questions:

--Is the new plant needed to satisfy projected demand for DOE enrichment services? GAO concluded it is not. DOE currently forecasts that it will be supplying enrichment services for 266 gigawatts of electricity by the year 2000, whereas GAO believes a more realistic estimate is between 184 and 217 gigawatts. At 217 gigawatts, DOE's existing enrichment capacity is sufficient through the year 2000 and beyond. (See p. 10.)

--Will the new plant enable DOE to substantially reduce the long-range costs--and therefore the prices--of its enrichment services? DOE believes it will but GAO is unconvinced. The disagreement centers around the projected demand for enrichment services and the availability and economics of an advanced isotope separation facility. DOE's economic justification for building the gas centrifuge plant is based on an October 1980 "Uranium Enrichment Strategy Study." The different options presented in the study generally show that building the gas centrifuge plant is economical at a high demand of 350 gigawatts or if DOE is unable to develop an advanced isotope separation technology. It is not economical at a lower demand of 250 gigawatts in the year 2000, and is even less economical at the lower demand levels estimated by GAO, if DOE successfully develops this advanced technology. (See pp. 15 and 17.)

GAO points out, however, that the relative cost differences between building and not building the centrifuge plant--in both DOE's and GAO's analysis--may not be significant when one considers that these economic analyses depend on projections of costs and other assumptions 31 years into the future.

For example, using GAO's expected demand of 217 gigawatts in the year 2000, the present value cost of providing enrichment services over a 31-year period is about \$59.5 billion if the gas centrifuge facility is built and \$58.7 billion if it is not built, or \$800 million less--a 1.3 percent difference. Such a relatively small difference in cost over such a long period may not be significant when deciding which option is the most economical and thus must be viewed with caution. Adding to this uncertainty are some technical problems GAO found in the computerized model used by DOE to develop its economic justification. (See pp. 16 and 23.)

--Is the new plant likely to improve DOE's competitive position in the world enrichment services marketplace? Even if the new plant offered long-range cost (and price) reductions, it is unlikely that DOE's competitive position would improve. Potential foreign enrichment services customers are as interested in other factors, such as assurance of supply and being subject to U.S. nuclear non-proliferation policies, as they are in price. Furthermore, a number of foreign countries are either partners in existing enrichment services operations or are interested in developing their own enrichment capabilities. (See p. 21.)

Constructing the gas centrifuge plant on the current schedule is clearly economical under a scenario of high demand for enrichment services or failure of the advanced isotope separation technology. The current trend, however, points to even further deterioration in nuclear power growth expectations. Furthermore, DOE currently expects to successfully develop the advanced isotope separation technology.

GAO recognizes that sudden events could cause a sharp reversal in the outlook for nuclear power. If this should happen, new enrichment capacity can be brought on line faster than new nuclear power plants. For example, it currently takes 12 to 14 years to bring a nuclear power plant on line, whereas a new enrichment facility takes about 10 years.

In the long run, DOE's enrichment services customers--primarily domestic and foreign

utilities--will pay for construction of the gas centrifuge plant. Short-run budgetary impacts, however, are significant, particularly in a period of increasing pressure to reduce the Federal budget. The budgetary options, expressed in fiscal year 1983 dollars, include:

- Continue the project on schedule. This would require an additional \$5.5 billion in appropriations through fiscal year 1994.
- Terminate the project immediately. This would reduce the need for appropriations by about \$5.1 billion through 1994.
- Slow the project one or more years. This would reduce appropriation needs in early years, but would add to overall costs.
- Complete only the portion now under construction. This would require an additional \$2.2 billion in appropriations. (See p. 27.)

While offering budgetary savings, the option to complete only the part now under construction would increase rather than decrease the cost of DOE enrichment services. According to DOE, the cost of enriching uranium in this scaled-down plant would be about three times as expensive as enriching uranium in the existing enrichment plants and in the entire gas centrifuge plant. This is because completing only the portion now under construction will cost about \$3.7 billion--a little more than one-half the cost of the entire gas centrifuge plant--but will produce only up to one-sixth of the amount of enriched uranium. The relatively high capital cost of the scaled-down plant is due to the need to complete the many centrifuge machine process building support facilities which were designed to support eight rather than two process buildings. Therefore, strictly from an enrichment services cost standpoint, it would be better to build the entire plant than only the portion now under construction. (See p. 29.)

MATTERS FOR CONSIDERATION
BY THE CONGRESS

GAO's work shows that building the centrifuge plant is not justified at current expected

demand levels. On the other hand, constructing the plant is economical if events cause a sudden increase in the demand for nuclear power or if DOE's efforts to develop advanced isotope separation technology fails. If either of the events occur, however, DOE has sufficient time to build new capacity.

Further, it seems clear that completing only the part of the plant currently under construction offers no economic advantages.

There are other considerations the Congress should weigh in addition to the information presented in this report. These considerations revolve around judgments about the future growth of nuclear power; the perceived importance of early replacement of the gaseous diffusion plants with the more energy efficient gas centrifuge technology; the social impacts of terminating the plant; and the advantages or disadvantages to the Tennessee Valley Authority, DOE's principal electric power supplier, of DOE using additional power for the gaseous diffusion plants if the centrifuge plant is not built.

The Congress should consider the information presented in this report along with information on these and other relevant factors in making future funding decisions on the centrifuge plant. In addition, because of the economic disadvantages of only completing the first portion of the plant, GAO believes that the Congress should view a decision to build the first increment of centrifuge production as a commitment to build the entire plant.

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At the request of the Chairman, Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, in order to provide this report in time for use during the appropriation process, GAO did not obtain DOE's comments on this report. Because of the expressed concern of several members of Congress, GAO plans to ask DOE to provide GAO its comments on the report. The comments will be carefully evaluated and, as appropriate, supplemental information furnished to the Congress.

CHAPTER 2

OUR ANALYSIS OF AND RESPONSE TO DOE'S

COMMENTS ON THE RISKS OF NOT BUILDING

THE GAS CENTRIFUGE PLANT

In its August 2, 1982, comments on our issued report, DOE said that the report does not reflect an objective or comprehensive review of DOE's justification for the gas centrifuge plant, but selectively and narrowly focuses only on certain elements of DOE's enrichment analysis. DOE also expressed continued support for the gas centrifuge plant project as critical to its efforts to remain competitive in the world enrichment marketplace.

The thrust of DOE's position is contained in the following paragraph excerpted from its comments:

"The justification for GCEP [gas centrifuge enrichment plant] can be summarized quite simply: without GCEP, the United States will price itself out of the enrichment business. Even at reduced demand levels, the cost of production from GCEP in current-year dollars will be significantly lower than production from the existing electricity intensive gaseous diffusion plants (GDPs). When escalation is factored in, the difference between GCEP and GDPs becomes very large. The rapid deployment of enrichment technologies capable of reducing U.S. production costs is a necessary and prudent business decision. The U.S. centrifuge technology is the most advanced proven enrichment technology in the world and offers the U.S. the opportunity to halt the erosion in our existing enrichment contract base and to regain its leadership and market share in the international nuclear community. The AIS [advanced isotope separation] technology currently under development by the Department offers the promise of even lower future costs but must reach a much higher stage of development before it can be counted on for production planning." (See p. 27.)

DOE believes that the gas centrifuge plant can ensure it a larger role in the world enrichment market by making its enrichment prices competitive. DOE, while recognizing the promise of the new AIS technology, dismisses its potential economic benefit on the basis that the technology is in too early a stage of development to be counted on for production planning.

In our report, we presented information on the issues which DOE's decision to build the gas centrifuge plant was based.

Although our findings did not lead us to the same conclusion DOE has reached, we believe that DOE has correctly identified the central issue on which a decision to build or not to build the plant should be based. That issue is the risk the United States would be taking by not building the plant as compared to the costs of avoiding this risk. This chapter is an evaluation of DOE's comments pertaining to this issue. In addition, the chapter discusses DOE's recent decisions to accelerate development of two advanced enrichment technologies because these technologies directly affect the risk issue.

WHAT IS THE RISK OF NOT BUILDING THE GAS CENTRIFUGE PLANT?

In 1975 there was a clear need for additional uranium enrichment capacity when the Congress authorized what is now the \$7 billion (fiscal year 1983 dollars) gas centrifuge plant project. Since that time, however, expected demand for DOE enrichment services through the year 2000 has decreased to an amount less than the production capabilities of DOE's three existing enrichment plants. It is that change which leads to consideration of alternative enrichment capacity strategies. The following sections present DOE's comments, and our evaluation of these comments, relating to the risks associated with not building the gas centrifuge plant as planned by DOE.

Economic risk

DOE acknowledged that, based on the assumptions we used in the economic analysis we performed and described in our report, it is slightly less costly to provide enrichment services by canceling the gas centrifuge plant and building new enrichment capacity using the AIS technology DOE is developing when it becomes available in the mid-1990's. DOE also said, however, that this action is too risky because the AIS technology cannot yet be counted on for production planning. DOE was also concerned that slippage in the AIS introduction date would erode its potential economic advantage. DOE stated that:

"In GAO's economic analysis, they estimate a cost advantage in meeting demand with the GDPs plus AIS capacity but without GCEP. This is the same result as previously indicated by DOE in the 1980 Strategy Study if it were possible to assume complete success of the AIS program. This slight savings disappears quickly if AIS fails to meet the 1995 target commercialization date. * * * Using all of GAO's recommended assumptions, the net present value savings of replacing GDP capacity with * * * AIS alone * * * is \$0.5 billion better than building GCEP and AIS together. However,

just a 1-year slip in AIS availability with no increase in cost eliminates this \$0.5 billion AIS advantage. If AIS slips 5 years, then building GCEP has a \$2.1 billion advantage." (Underscoring supplied.) (See p. 31.)

* * * *

"In our view, to make a case for cancelling GCEP on the basis of cost and schedule projections for a technology that will not demonstrate production readiness until the end of this decade would be unwise." (See p. 32.)

We did not verify the calculations DOE made to estimate the cost of a 1-year and 5-year slip in the AIS technology. DOE's estimates appear consistent, however, with our report. As stated on page 17 of our issued report, if DOE's AIS program does not work as anticipated or costs are considerably greater than anticipated, then building the gas centrifuge plant becomes more economical in the long run even at low demand levels.

We also pointed out in our report that DOE's existing enrichment capacity is high enough that DOE would still have time to build new capacity if the AIS technology fails. For example, if AIS failed, DOE could use the advanced centrifuge technology it intended to install in the last six of the eight gas centrifuge plant buildings or, if DOE's even more advanced centrifuge machine development program is successful, DOE might be able to use this technology.

Risk to DOE's competitiveness in the world enrichment market

DOE's primary reason for building the gas centrifuge plant is that it believes the plant is the essential ingredient to offering competitively priced enrichment services, thereby enabling it to successfully compete for new enrichment services contracts in the limited world market. DOE states that:

"The GAO analysis of the impact of GCEP termination on the enrichment market suffers from an outdated perception of the market. Based upon extensive contact with the enrichment customers, we are convinced that cancelling or delaying GCEP would seriously affect the competitive position of the U.S. in the international market. The market has changed considerably since 1980 when GAO issued its report on U.S. Nuclear Non-Proliferation (EMD-81-9, November 18, 1980), which serves as the basis for the GAO conclusion that GCEP is unlikely to improve DOE's competitive position.

Two specific examples of how the market has changed are:

1. In 1980 the U.S. was not perceived to be a reliable nuclear supplier. We were perceived as making supplier decisions based predominantly on the basis of a non-proliferation standard that applied to all countries without regard for individual country non-proliferation performance. The Reagan administration has made great progress in reestablishing the credibility of the U.S. as a reliable supplier by looking at the merits of individual country non-proliferation performance.
2. The U.S. has lost the sizeable price advantage we enjoyed in 1980.

"The U.S. has experienced a dramatic decline in foreign sales of enrichment services, from a 100 percent market share in 1974 to about 35 percent in 1980. A combination of factors in addition to price contributed to this phenomenon, including supply diversification needs, supply assurance, national goals and politics. However, our customers have consistently repeated since 1981 that these other factors are now relatively insignificant and future purchase decisions will be based primarily upon the availability of low enrichment prices and the reasonable predictability of low prices in the future." (See p. 28.)

DOE may be correct in its statement that Reagan administration policies have allowed the United States to make great progress in reestablishing the credibility of the United States as a reliable nuclear supplier. However, no guarantee exists that future administrations will choose to pursue similar policies. Furthermore, because DOE's enrichment service contracts usually cover a 30-year period, we do not agree with DOE's observation that the non-price aspects of the U.S. enrichment program--such as supply diversification and supply assurance--have become relatively insignificant.

Regarding DOE's comment that the gas centrifuge plant will enable it to offer more competitive enrichment services prices, we believe that one needs to recognize DOE's limited control over its selling price. DOE is required by law to provide enrichment services on a cost recovery basis. It does not have as much flexibility as its foreign competitors in pricing its enrichment services. For example, the Soviet Union has routinely charged slightly less for its enrichment services than DOE. In

addition, another foreign supplier--Eurodif--recently reduced its enrichment price below DOE's. Reportedly, the reduction was made possible by a policy decision to lower prices through Government subsidies to the enricher. Therefore, even assuming that constructing the gas centrifuge plant would enable DOE to enrich uranium more cheaply than its competitors, this would offer no long-term assurance that DOE's competitors would not choose to subsidize their enrichment operations and underprice DOE, thus eliminating the competitive price DOE now cites as the rationale for building the gas centrifuge enrichment plant.

Finally, some of DOE's traditional foreign customers have become members of enrichment consortia, such as Eurodif and URENCO. Eurodif includes France, Spain, Belgium, and Italy, while URENCO includes the United Kingdom, West Germany, and the Netherlands. Now, as members of an enrichment consortium, former and potential DOE customers in these countries may be obligated, or find it economically desirable, to purchase enrichment services through their respective consortium. For example, both Spain and West Germany have terminated contracts with DOE in order to purchase enrichment services from Eurodif and URENCO, respectively.

Risk of inadequate enrichment capacity if the gas centrifuge plant is not completed

The Congress originally authorized additional enrichment capacity in December 1975 because demand for DOE's enrichment services was expected to exceed existing enrichment capacity by fiscal year 1982. Since that time, there has been a significant decrease in expected demand for DOE enrichment services. DOE now agrees with the results of our analysis which show this significant decrease in demand. In commenting on our report, DOE stated that:

"Based upon recent developments, we agree that the year 2000 demand projections contained in our last year's forecast have further eroded. Our most recent preliminary assessment is that our new mid-range forecast by the year 2000 will be closer to the GAO forecast of 217 gigawatts." (See p. 29.)

DOE's existing gaseous diffusion enrichment plants are capable of providing the enrichment services needed to satisfy a demand of about 240 gigawatts, or about 23 more than our 217 gigawatt high forecast for the year 2000. Furthermore, these plants have continuously operated with a production reliability factor of more than 99 percent. Thus, DOE's existing gaseous diffusion enrichment capacity alone will be more than sufficient to satisfy expected demand through at least the year 2000.

Although demand was the initial justification for the gas centrifuge plant, DOE's current justification is that the rapid deployment of more efficient enrichment technology is a necessary and prudent business decision.

WHAT ARE THE BUDGETARY COSTS OF
AVOIDING THE RISK THAT DOE'S AIS
TECHNOLOGY WILL NOT BE SUCCESSFUL?

As discussed earlier, DOE plans to avoid the risks it would face if the AIS technology program does not meet its objectives by building the gas centrifuge enrichment plant. DOE believes this is a necessary and prudent business decision. This section evaluates DOE comments related to the budgetary costs of ensuring against lack of success in developing the AIS technology.

In its comments, DOE agreed that an additional \$5.8 billion (fiscal year 1983 dollars) would be required to complete the gas centrifuge plant as planned. (See p. 39.) This means that DOE will need to spend between \$500 million and \$600 million per year through 1990, plus about another \$1 billion in fiscal years 1991 through 1994 (fiscal year 1983 dollars).

DOE also pointed out, however, that our report

"* * * fails to mention that uranium enrichment revenues have been more than sufficient to cover all uranium enrichment appropriation requirements including GCEP over the FY 1982 and FY 1983 period. DOE anticipates that this trend will continue. Therefore, the uranium enrichment program does not require net appropriation, nor does it contribute to the national debt." (See p. 39.)

DOE is not technically correct in stating that uranium enrichment revenues have been more than sufficient to cover all appropriation requirements. In fiscal year 1982, according to the President's fiscal year 1984 budget, DOE's total actual uranium enrichment program appropriation exceeded revenues by slightly more than \$84 million. For fiscal year 1983, according to the budget, revenues are estimated to equal total enrichment program obligations.

More importantly, DOE's conclusion that the uranium enrichment program does not contribute to the national debt, while perhaps technically correct, does not accurately convey the impact of DOE's overall enrichment program--including construction of the gas centrifuge plant--on the Federal budget.

DOE is required by law to recover all of its enrichment costs over a reasonable period of time. To do this, DOE establishes a price for its enrichment services which includes a number of cost components. Some of these components, such as electric power, operating, and process development costs, represent actual expenses DOE must pay others. Other cost components in DOE's enrichment services prices include depreciation of plant and equipment and imputed interest on the Government's investment in the uranium enrichment program. Unlike the former cost components, these do not consist of actual expenses DOE must pay others. Therefore, because DOE charges its customers for these latter costs but does not pay these costs out of its appropriations, DOE may generate enough revenue from its uranium enrichment program to pay the expenses of producing enriched uranium and also for activities such as constructing the gas centrifuge plant.

In fiscal year 1982, for example, of the \$1.7 billion in enrichment services revenues DOE collected, approximately \$676 million was collected to cover imputed interest on the Government's investment in the enrichment program. Because imputed interest is not an out-of-pocket expense to DOE, however, DOE was able to use revenues derived from imputed interest for expenses such as paying for gas centrifuge plant construction in that year.

If DOE was not building the gas centrifuge plant, its expenditures for uranium enrichment would be reduced accordingly. It would, however, still collect revenues to recover both its current year out-of-pocket costs of enriching uranium and other costs to the Government such as depreciation and imputed interest. Without a need for the revenues collected to recover depreciation and imputed interest costs, however, these revenues--which represent recovery of the costs of enrichment services and not profit--could be made available to pay other Government expenses. Thus, in this situation these funds could be used to reduce annual Federal budget deficits and, therefore, reduce the contribution of an annual budget deficit to the growing national debt.

DOE also said that our report

"* * * is also wrong in stating that GCEP costs will not be recovered until 1989. In fact, \$25 per SWU [separative work unit] of the recently announced price is related to recovering GCEP costs, primarily recovering interest costs on construction work in process." (See p. 40.)

What our issued report states, on page 28, is that the \$5.8 billion in expenditures needed to complete the gas centrifuge

plant "* * * and interest on them will eventually be paid back to DOE * * * beginning in 1989, over the operating life of the plant." We then stated that DOE includes in its enrichment price an amount for depreciation of its enrichment plants and an amount for interest on the use of Federal funds to construct its enrichment plants. DOE is correct that it is now recovering interest costs on gas centrifuge plant construction work in process.

RECENT DOE DECISIONS TO
ACCELERATE DEVELOPMENT OF
ADVANCED ENRICHMENT TECHNOLOGIES

Our May 1982 report and DOE's August 2, 1982, comments were based on DOE's overall uranium enrichment program as it existed then. Since August 1982, however, DOE has decided to accelerate its programs for developing both the AIS technology and the more advanced gas centrifuge machine technology.

When DOE commented on our report, it had planned to construct and begin operating an AIS demonstration facility by 1988 or 1989. DOE expected this could enable it to decide whether to build a production plant using this technology in 1990, and if so, to complete the production plant in the mid-1990's. DOE has now decided to modify its development strategy by canceling the demonstration project and expanding its use of an existing laboratory to accommodate the most important features of the demonstration project. DOE believes that its revised strategy will enable it to advance the production plant decision date from 1990 to 1987.

At the time DOE commented on our report, it had planned to begin developing a gas centrifuge machine in about 1984 which, if successful, would be even more efficient than the advanced machines it currently plans to install in the last six buildings of the gas centrifuge plant. In January 1983, however, DOE also began to accelerate this development program. DOE believes that an accelerated development schedule is warranted based on the availability of improved materials and the excellent results it has obtained in developing the centrifuge machines it plans to install in the gas centrifuge plant.

DOE's current gas centrifuge plant project plans do not include initial installation of these more advanced machines in the plant before it is completed in 1994. DOE now believes, however, that if its accelerated program is successful, the more advanced machines could be available in 1991 for installation in the last four of the eight gas centrifuge plant buildings. DOE believes that these more advanced centrifuge machines have the potential for being twice as efficient as the centrifuge machines it currently plans to install in the last six buildings of the gas centrifuge plant.

CHAPTER 3

OUR ANALYSIS OF AND RESPONSE

TO OTHER DOE COMMENTS

Many of DOE's comments on our issued report were not directly related to the risks inherent in not building the gas centrifuge plant and the costs of avoiding those risks. These other comments addressed (1) future demand for DOE enrichment services and the importance of demand to gas centrifuge plant economics, (2) other aspects of our economic analysis, (3) electric power issues, (4) budgetary impacts of either terminating the gas centrifuge plant project or completing only the portion now under construction, and (5) the balance of payment effects of DOE's sales of enrichment services. These DOE comments, and our evaluation of them, are discussed below.

ENRICHMENT SERVICES DEMAND AND ITS IMPORTANCE TO GAS CENTRIFUGE PLANT ECONOMICS

As noted on page 11, DOE agrees with the results of our analysis which show that there has been a significant decrease in the amount of expected demand for its enrichment services. However, DOE disagrees that this would affect its plans to build the centrifuge enrichment plant. DOE stated that:

" * * * the conclusion that we need GCEP to maintain the commercial viability of U.S. enrichment is valid based upon any responsible demand forecast, including the GAO numbers." (See p. 29.)

In discounting the effect of decreases in demand on the need to build the centrifuge plant, DOE disagreed with our characterization of demand as being the most critical factor affecting the economics of building the gas centrifuge plant. DOE stated that:

"GAO questions the economic benefits of GCEP by assuming that demand is by far the most critical factor affecting GCEP economics. This is not true. While demand is an important factor, more important considerations are the introduction date and cost of AIS, power cost escalation, general inflation, and GCEP cost." (See p. 30.)

We agree that the factors DOE identified are all important in evaluating the economics of building the gas centrifuge plant. We continue to believe, however, that demand-- specifically the major decrease in projected demand for DOE

enrichment services which has occurred in recent years--has had a major impact on the economics of the gas centrifuge plant project.

We reached our conclusion that demand is crucial to gas centrifuge plant economics after we made a number of sensitivity analyses to account for variations in demand, electric power cost escalation rates, the general inflation rate, and gas centrifuge plant costs. Variations in any one of these economic factors affected the projected long-range costs of DOE enrichment services. Except for demand, however, variations in these factors had little impact on the overall economics of building the gas centrifuge plant. However, when (1) demand was assumed to be 217 gigawatts in the year 2000 and (2) the AIS technology was assumed to be successful, our economic analysis showed that building the gas centrifuge plant would not be economical.

Finally, as noted on page 15 of our issued report, DOE's Uranium Enrichment Strategy Study showed that building the gas centrifuge plant, followed by one AIS enrichment facility in 1995, is economical at a demand of 350 gigawatts in the year 2000. On the other hand, the study showed that building the gas centrifuge plant is uneconomical at 250 gigawatts--30 gigawatts more than DOE's current forecast for enrichment services demand in that year.

OTHER ECONOMIC ANALYSIS ISSUES

DOE commented on several other aspects of the economic analysis we prepared and discussed in our report. Specifically, DOE (1) questioned our exclusive reliance on a DOE economic model, (2) concluded that we understated the expected rate of escalation of electric power costs, and (3) criticized our handling of gas centrifuge plant and AIS plant cost estimates.

Our use of DOE's economic model

DOE believes that one reason we concluded that the centrifuge plant is uneconomical is because we used the economic model in our analysis which DOE used in preparing its 1980 Uranium Enrichment Strategy Study. DOE stated that:

"GAO's analysis of DOE's economic justification of GCEP is incomplete and inaccurate. GAO focused on the DOE economic model (EDIC) used in the 1980 Strategy Study in evaluating DOE's economic justification for GCEP. Other analyses have been performed, as reported in the December 1981 Operating Plan Paper. Comparisons of the unit cost of product and future prices of enrichment services have also been prepared. All of these analyses support DOE's claim that completing

GCEP will lower the costs of uranium enrichment and provide assurance that enrichment costs will not escalate rapidly if AIS is not available." (See p. 30.)

In determining which of DOE's enrichment documents and computerized models to analyze in evaluating the economics of building the centrifuge plant, we met with DOE officials and identified the different studies performed by them and obtained explanations of how the studies were used. During these meetings DOE identified, among other documents, the December 1981 Operating Plan Paper mentioned on the previous page. Our review of that paper revealed that the time period covered in its analysis makes it less appropriate for evaluating the economics of various enrichment capacity expansion alternatives than the DOE economic model we used.

DOE's operating plan paper covers only the 20 years from 1983 through 2002. This period includes only about 9 years of operation with the full capacity gas centrifuge plant, and only about 7 to 8 years of potential operation of an enrichment plant using the AIS technology. As noted in our issued report, one of DOE's objectives with the AIS technology program is to enrich uranium at a cost of about one-half that of the gas centrifuge plant. With this large cost differential, the 20-year time frame covered in DOE's operating plan paper penalizes the economics of the AIS technology compared to the gas centrifuge plant project because many of the potential economic benefits of the advanced technology will be realized after 2002.

Furthermore, while DOE's operating plan paper analyzes 11 basic cases involving major assumptions such as demand, centrifuge plant costs and schedule, and electric power costs, only 1 of the 11 cases included introduction of the advanced isotope separation technology. That case, however, also uses DOE's former 266-gigawatt demand level. The 20-year time period in the analysis shows that whether or not it is economical to complete the gas centrifuge plant depends on future electric power costs. In discussing this case, DOE's paper states that:

"The above shows that there is a possibility that AIS availability in the mid-1990's timeframe could make it more economical not to proceed with GCEP. However, given the current status of AIS technology development and the uncertainties therein, the likelihood of AIS availability in the mid-1990's at projected costs cannot be ascertained at this time."

Thus, even at the high demand and the shorter time period, which excluded much of the potential economic benefits of DOE's AIS technology, DOE concluded that successful deployment of the advanced technology in the mid-1990's could make it more economical not to build the gas centrifuge plant.

For our economic analysis, we selected the computer model which DOE used in preparing its October 1980 Uranium Enrichment Strategy Study. We made this selection because this model, which covered a 31-year period, was better suited than the models DOE used in preparing its Operating Plan Paper for evaluating long-range economics of alternative enrichment facilities. With the exception of changing key input assumptions to the model, such as enrichment services demand, we made no changes to the DOE model or data used in the model.

Our analysis showed that, based on the key assumptions we developed and used, the gas centrifuge plant will probably only be economical if (1) there is a sudden increase in demand for nuclear power or (2) DOE's AIS technology program fails. When compared to exclusive reliance on the gaseous diffusion plants, we agree that completing the gas centrifuge plant will both lower enrichment costs and provide assurance against rapid enrichment cost escalation at levels of demand consistent with our enrichment services demand estimate of 217 gigawatts in the year 2000. However, should the year 2000 demand be closer to our lower range of 184 gigawatts, building the gas centrifuge enrichment plant will only offer nominal economic benefits even if the AIS enrichment technology fails.

Electric power cost escalation rate

Because the existing gaseous diffusion enrichment plants use large amounts of electric power, future electric power costs are important to any analysis of enrichment plant economics. DOE believes that for our economic analysis we selected an electric power cost growth rate which was too low. DOE stated that:

"In structuring its economic analysis, GAO projected constant dollar electric power cost escalation of 0.4 percent per year through 1990 and 0 percent thereafter. This results in a 1990 rate that is only 3.2 percent higher than today's rate in constant dollars."
(See p. 30.)

DOE believes that our power cost escalation rate projection is not consistent with the Energy Information Administration (EIA) projection as we stated in our report. DOE stated that our projection is three to four times less than EIA's projection.

In comparing our rate projection with EIA's, it is important to recognize that our power cost escalation rate relates to a constant dollar cost that is different than the rate EIA used in its report. We reported an escalation rate relative to constant dollars, adjusted for increases in capital expenditures

and nonpower operating costs, as DOE did in preparing its October 1980 Uranium Enrichment Strategy Study. On the other hand, the EIA rate DOE mentioned in its comments showed power cost escalation rates relative to constant dollars adjusted for increases in the gross national product (GNP). Therefore, the power cost escalation rate figures we reported (0.4 percent through 1990 and 0 percent thereafter) and EIA reported (1.2 to 1.7 percent from 1980 through 1995) cannot be compared, as DOE did, without first adjusting one set of data so that it is relative to the same type of constant dollars as the other set.

Specifically, our rate of power cost escalation of 0.4 percent per year through 1990 and 0 percent thereafter is the rate we estimate that power costs will exceed constant prices adjusted for increases in capital expenditures and nonpower operating costs. The EIA rate of between 1.2 and 1.7 percent per year is the rate that they expect power costs to exceed constant prices adjusted for increases in the GNP--not for capital expenditures and nonpower operating costs. For comparison purposes, when we adjust our rate so that it is also relative to constant prices adjusted for increases in the GNP, it shows the rate of power cost escalation to be 1.6 percent per year, the same as the uppermost range of the rates of escalation DOE's comments attribute to EIA. Thus, EIA's power cost escalation rate is not three to four times as large as ours, but actually confirms our electric power cost escalation rate projection.

Gas centrifuge plant costs

DOE criticized our report for the way we handled contingency costs for the gas centrifuge plant and the AIS technology in our economic analysis. DOE stated:

"We have confidence in our GCEP construction cost estimate. To date, the estimated cost has remained stable with the exception of escalation and costs associated with the revised schedules. * * * We have bid experience on 90 percent of the construction and procurement packages, other than the centrifuge machines. The centrifuge machine cost is 40 percent of the plant cost. The only estimating difficulty in the centrifuge plant is the rotor. The cost associated with the rotor represents less than one-fourth of the total machine cost, or less than 10 percent of the total project cost."

* * * *

"The GAO report does not recognize that the current cost estimate does include a contingency of 15 percent for machine costs and 10 percent for the entire project." (See p. 32.)

On page 18 of our issued report, we stated that both the gas centrifuge plant construction project and the centrifuge machine development schedule were proceeding within cost and schedule objectives. However, as we also stated, major elements of the centrifuge program remain to be undertaken and/or completed. These elements will bear on the eventual cost of enriching uranium at the plant.

We were aware that DOE's official gas centrifuge plant construction cost estimate contained a 10-percent allowance, including a 15-percent allowance for centrifuge machine costs. However, given the early stage of the project and machine development, as described above, we believe that it is reasonable to escalate the project cost estimate by 10 percent for the purpose of sensitivity analyses to determine the impact of potential cost overruns. We found that cost overruns of this amount did not in themselves make the centrifuge plant uneconomical.

More importantly, as discussed on page 16 of our issued report, our conclusion that constructing the gas centrifuge plant is uneconomical unless the AIS technology fails was not based on escalating gas centrifuge plant construction and operating costs by 10 percent. Rather, it was based on our 217 gigawatt estimate of demand for DOE enrichment services by 2000.

DOE also criticized the fact that we escalated gas centrifuge plant costs 10 percent but did not do so for the AIS technology. DOE stated that:

"The GAO analysis was also not objective in its treatment of the relative uncertainties of GCEP and the AIS technologies. An analysis which assigns a cost penalty to the proven gas centrifuge technology and no penalty to the less developed AIS technology is not an objective analysis." (See p. 30.)

We do not agree with DOE's position that our analysis was not objective. We did add 10 percent to DOE's centrifuge plant cost estimate to determine the effect of a cost overrun on the plant's long-range economics. We did not make an equivalent adjustment to DOE's AIS technology construction and operating cost estimates, however, because these estimates already include large (about 30 percent of total cost) cost contingencies.

ELECTRIC POWER ISSUES

DOE commented on three issues related to its use of electric power for the existing gaseous diffusion enrichment plants and the potential impacts of canceling the gas centrifuge plant on DOE's ability to efficiently manage its purchases of electric

power. The issues were (1) potential penalty charges on electric power under contract but not used, (2) terms and conditions of future electric power contracts, and (3) future electric power budgets.

Power contract penalty charges

When DOE does not use all of the power it has agreed to purchase, it pays a penalty, known as a capacity charge, to its electric power suppliers. In its comments DOE stated that:

"By 1990, one of two scenarios would result if GCEP were cancelled. If AIS is successful, then DOE must either terminate some of the power contracts and pay capacity charges or delay implementing AIS until the capacity charges can be avoided. Either option is uneconomical. If AIS is unsuccessful, then the GDP would be our only capacity, and, clearly, we would be at a major price disadvantage with our competitors."
(See p. 31.)

DOE apparently considers the first scenario unacceptable because it would have to either pay capacity charges or delay implementing AIS. However, this is the same choice DOE now faces with the centrifuge plant. In this case DOE has chosen not to delay the centrifuge plant in favor of increasing production rates to avoid paying capacity charges. Instead, DOE has chosen to operate its existing enrichment plants at minimum levels, pay the capacity charges on the electric power it has contracted for but does not use, and to introduce the gas centrifuge technology on its current schedule. DOE's justification for this approach is that the capacity charges it now pays will be offset by the savings gained from using the more economical centrifuge enrichment technology when it becomes operational. The same logic could be applied to the AIS technology.

Regarding the second scenario--failure of DOE's AIS technology--DOE states that it would be at a major price disadvantage because only the gaseous diffusion plants would be available to DOE. Our comments on this risk were discussed earlier on page 8.

Future electric power costs

DOE believes that we were optimistic with respect to its future electric power contracts. DOE stated:

"Furthermore, GAO has not included in their analysis the impact of all of DOE's power contracts that expire in the early 1990's. The terms and conditions of new

power contracts could be less favorable which correspondingly would increase long-term power costs." (See p. 30.)

DOE is correct that the terms and conditions of new power contracts could be less favorable. However, given the current surplus of electric generating capacity and the 10 years which remain until the contracts expire, it seems reasonable that DOE and its electric power suppliers may be in a situation where economics would encourage them to explore contract terms which best accommodate both of their needs. Failure to do so could result in the power suppliers having additional surplus power and DOE not being able to enrich uranium as economically as possible.

Future electric power budgets

DOE believes that canceling the centrifuge plant could result in increased power budgets. DOE stated that:

"Without GCEP, additional production would have to come from the existing gaseous diffusion plants. The timing of production from diffusion capacity could be earlier than production from GCEP in order to minimize production costs. Accordingly, power budgets could be higher prior to 1988, thus mitigating the impact of reduced GCEP costs. There would also be decreased revenues in the next several years." (See p. 33.)

DOE is correct that without the centrifuge plant some additional production would have to come from the existing gaseous diffusion plants. Whether or not the gaseous diffusion plant production "could be earlier than production from GCEP to minimize production costs," as DOE stated, revolves around two issues. One issue is whether it is more economical to enrich uranium with the existing diffusion capacity in advance of demand or wait and produce the enriched uranium at a later date with the more economical AIS technology. This is the same issue DOE recently experienced when it decided to operate the existing diffusion plants at minimum capacity until the more economical centrifuge plant becomes available. The second issue is the budget. In this case a trade-off may be made between minimizing long-term production costs and reducing near-term annual budgets. Early year budgets could be larger in order to minimize long-term production costs, or early year power budgets could remain the same if priority is given to keeping down near-term annual budgets.

Regarding DOE's claim that revenues would decrease with termination of the gas centrifuge plant, it is important to remember that by law DOE can only recover its enrichment costs.

Therefore, decreases in revenues must be caused by corresponding decreases in costs. For this reason, we fail to see the significance of DOE's concern over a revenue decrease being caused by the termination of the centrifuge project.

BUDGETARY IMPACTS OF TWO GAS
CENTRIFUGE PLANT OPTIONS

In our issued report, we discussed the budgetary impacts of completing the gas centrifuge plant project as planned, terminating the project, completing only the portion of the plant now under construction, and slowing the current construction schedule. DOE's comments on completing the plant were discussed on page 12. DOE agreed with our report's presentation of the budgetary impact of slowing the gas centrifuge plant construction schedule. (See p. 41.) DOE did not completely agree, however, with our report in the other two areas.

DOE said that our report did not accurately describe the budgetary impact of terminating the gas centrifuge plant project. DOE said:

"GAO does not accurately provide the budgeting impacts of terminating GCEP. Should GCEP be terminated at the end of fiscal year 1982, the budget authority request for fiscal year 1983 for GCEP could be reduced from \$613 to \$350 million. The \$350 million would be needed to pay termination costs for existing GCEP-related contracts. In addition, uranium enrichment revenues would decrease by about \$112 million in 1983 because GCEP costs would be deleted from the cost recovery charge. The net impact on the 1983 budget would be a decrease in the budget authority request of \$151 million.

"Budget outlays for FY 1983 would actually increase from \$215 million to about \$700 million and thus work contrary to our efforts to balance the FY 1983 budget. This happens from spending the additional \$350 million in budget authority that would be needed [for contract termination costs] plus spending the end of FY 1982 commitments." (See p. 32.)

DOE is correct that budget outlays for fiscal year 1983 might increase from \$525 million to about \$700 million. We indicated this in our report, on page 28, where we recognized that DOE said that termination of the project would require \$350 million of fiscal year 1983 funds for termination charges over and above \$342 million in outstanding commitments. However, while project termination could increase fiscal year 1983 budget

outlays by about \$175 million--from \$525 million to about \$700 million--planned fiscal year 1984 budget outlays of about \$600 million would be eliminated, and another \$4.6 billion in planned budget outlays in fiscal years 1985 through 1994 would also be eliminated.

DOE also said that we made two basic mistakes in our report in discussing the option of completing only the portion of the gas centrifuge plant now under construction. First, DOE said that we penalized the gas centrifuge plant by comparing the full cost of a two-building plant, in 1983 dollars, to the average cost of gaseous diffusion plant production in fiscal year 1981. (See p. 41.) In making this comparison, our intent was only to contrast wide differences in production unit cost between DOE's estimates for a two-building gas centrifuge plant and the existing gaseous diffusion plants. The most recent gaseous diffusion plant cost available to us was the fiscal year 1981 figure of \$87.50 per separative work unit. For comparison purposes, as stated on page 16 of our report, we reported that DOE estimated the cost of enriching uranium in the full gas centrifuge plant at \$81 (fiscal year 1983 dollars) per separative work unit.

Second, DOE said that we erred in including sunk costs in our comparison. DOE said:

"A decision maker can only affect future costs. Therefore, to arrive at a comparison that will result in the lowest cost of production, only incremental cost should be used for comparison. This type of comparison does not ignore the importance of sunk cost; it just recognizes that these costs have already been incurred.

"With making these corrections to the GAO analysis, the GCEP incremental cost in 1983 dollars for the first two buildings is \$114 per SWU. The comparable diffusion cost is \$108 per SWU. When any inflation rate is considered, the unit cost of GCEP becomes significantly less than diffusion by the time GCEP begins production. For example, by 1996 the two building GCEP will cost \$205 per SWU while diffusion will cost \$330 per SWU assuming nine percent inflation. This occurs because all of diffusion costs are subject to escalation, whereas GCEP has low operating costs (which are subject to escalation) and construction costs once spent do not escalate. For the full eight process buildings, the comparison in 1996 at nine percent inflation is \$130 per SWU for GCEP and \$270 per SWU for diffusion." (See p. 41.)

We agree that we included sunk costs in our comparison and believe that it was appropriate to do so in the context of the

point we were making. Our point was that there is a cost penalty associated with completing only the two process buildings plus related facilities which DOE's enrichment customers would have to bear in the form of higher enrichment prices. DOE's customers pay enrichment services prices based on full recovery of all DOE's costs--sunk and incremental.

According to DOE, the unit cost from this option would be either \$255 or \$177 (in fiscal year 1983 dollars), depending on the type of centrifuge machine installed in the plant. To demonstrate the significance of these unit cost estimates, we pointed out that in the then most recently completed fiscal year (fiscal year 1981), DOE's unit cost of enriching uranium in the gaseous diffusion plants was about \$87. As stated above, the estimated unit cost from the full-size gas centrifuge plant is \$81.

THE GAS CENTRIFUGE PLANT'S IMPACT ON THE U.S. BALANCE OF PAYMENTS

In commenting on why it considers the centrifuge plant important to the U.S. balance of payments, DOE stated that:

"We strongly disagree with GAO that this balance of payment impact is insignificant and can, therefore, be ignored." (See p. 39.)

Contrary to DOE's statement, we did not state that the balance of payment impact associated with DOE's enrichment program is insignificant and can therefore be ignored. What we stated in our report about the enrichment revenues is quoted in part below.

"Although a sizeable amount, this represented only slightly more than one-tenth of one percent of the total U.S. export revenues for that year."

The purpose of providing information on the relationship between DOE enrichment revenues and the overall U.S. balance of payments is to place the enrichment program's contribution to the balance of payments into perspective for decisionmakers.

EXPLANATORY NOTES TO APPENDIX I

In evaluating DOE's comments, we organized this supplement around (1) the risks of canceling the gas centrifuge plant, (2) the budgetary costs of avoiding risks, and (3) other DOE comments. For this reason, our evaluation does not address DOE's comments in the order of presentation in DOE's letter and enclosure.

To facilitate the reader's ability to review specific DOE comments and refer to our evaluation of those comments, we have made the following notations to the left-hand margin of paragraphs in DOE's letter and enclosure.

a--This note refers to DOE comments which we did not evaluate in this supplement because the comments (1) do not address the findings and conclusions of our report or (2) the comments address matters discussed in our report which are not important to understanding the issues concerning DOE's justification for building the gas centrifuge plant. In the latter case, we have added a note at the end of DOE's comment to explain why it was not important to evaluate the comment.

b--This note refers to DOE comments which are addressed in the letter at the beginning of this supplement.

page references--Page references refer to the pages in chapters 2 and 3 of this supplement where our evaluation of the DOE comment appears.



Department of Energy
Washington, D.C. 20585

AUG 2 1982

Mr. J. Dexter Peach
Energy and Minerals Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Peach:

a The Department of Energy (DOE) regrets that GAO was unable to request DOE
comments prior to issuing your May 25, 1982, report entitled "Issues Con-
cerning the Department of Energy's Justification for Building the Gas
Centrifuge Enrichment Plant." However, in the hope that GAO will issue a
supplemental report that is more objective and balanced, we are providing
our formal comments in response to your June 2, 1982, letter.

b In general, DOE finds the GAO report misleading, lacking in balance, and in
many areas, shallow in its findings and supporting evidence. The report
reflects an outdated view of the current international market environment
and is not objective in its analysis of GCEP versus the less proven Advanced
7 Isotope Separation (AIS) processes. The report does not reflect an objective
or comprehensive review of DOE's justification for GCEP, but selectively and
narrowly focuses only on certain elements of DOE's enrichment analysis. GAO
exaggerates the importance of minor analytical variables at the expense of
placing proper weight on those elements that form the real basis for DOE's
enrichment strategy.

a DOE continues to strongly support the need for GCEP based on the results of
the Department's thorough analyses of the alternatives available to the
enrichment enterprise. These analyses carefully examine various production
scenarios and evaluate the merits of each on the basis of cost, both to the
Government and to the customer; impact on U.S. enrichment prices and our
competitive position in the international market; energy efficiency; and
technical achievability. In all cases, continued construction of GCEP yields
superior benefits both to the Government and its customers in terms of
improved economics and production reliability.

The justification for GCEP can be summarized quite simply: without GCEP, the
United States will price itself out of the enrichment business. Even at
reduced demand levels, the cost of production from GCEP in current-year
dollars will be significantly lower than production from the existing electri-
city intensive gaseous diffusion plants (GDPs). When escalation is factored
in, the difference between GCEP and GDPs becomes very large. The rapid
deployment of enrichment technologies capable of reducing U.S. production
costs is a necessary and prudent business decision. The U.S. centrifuge

technology is the most advanced proven enrichment technology in the world and offers the U.S. the opportunity to halt the erosion in our existing enrichment contract base and to regain its leadership and market share in the international nuclear community. The AIS technology currently under development by the Department offers the promise of even lower future costs but must reach a much higher stage of development before it can be counted on for production planning.

U.S. Competitive Position

9 The GAO analysis of the impact of GCEP termination on the enrichment market suffers from an outdated perception of the market. Based upon extensive contact with the enrichment customers, we are convinced that cancelling or delaying GCEP would seriously affect the competitive position of the U.S. in the international market. The market has changed considerably since 1980 when GAO issued its report on U.S. Nuclear Non-Proliferation (EMD-81-9, November 18, 1980), which serves as the basis for the GAO conclusion that GCEP is unlikely to improve DOE's competitive position. Two specific examples of how the market has changed are:

1. In 1980 the U.S. was not perceived to be a reliable nuclear supplier. We were perceived as making supplier decisions based predominantly on the basis of a non-proliferation standard that applied to all countries without regard for individual country non-proliferation performance. The Reagan administration has made great progress in reestablishing the credibility of the U.S. as a reliable supplier by looking at the merits of individual country non-proliferation performance.
2. The U.S. has lost the sizeable price advantage we enjoyed in 1980.

The U.S. has experienced a dramatic decline in foreign sales of enrichment services, from a 100 percent market share in 1974 to about 35 percent in 1980. Today, the U.S. share of the foreign market remains at about 35 percent. A combination of factors in addition to price contributed to this phenomenon, including supply diversification needs, supply assurance, national goals and politics. However, our customers have consistently repeated since 1981 that these other factors are now relatively insignificant and future purchase decisions will be based primarily upon the availability of low enrichment prices and the reasonable predictability of low prices in the future.

- a DOE emphasized to all existing and potential customers that appreciable cost reductions are expected in the U.S. enrichment program by virtue of U.S. leadership in, and utilization of, advanced enrichment technologies. DOE's customers universally accept the concept that future enrichment prices will be more favorable with the incorporation of the more economical, less energy intensive, centrifuge technology being installed in GCEP.

b On May 10, 1982, Egypt signed three new 30-year enrichment contracts with the U.S. in addition to a modification of the one existing contract increasing the sales commitment by one-third. Sales from these four contracts are expected to total about \$1.5 billion. Since the first deliveries are not expected to be made until the early-1990's, the role of GCEP to assure low cost enrichment services over the long term was a major factor in securing this sale. There are additional foreign sales opportunities in the next few years for over 10 contracts with an annual sales value in excess of \$100 million (lifetime sales would represent about \$3.0 billion). These include new sales in Taiwan and Yugoslavia in addition to follow-on contracts in the Federal Republic of Germany, Switzerland, and the Netherlands. These customers have told us that price will represent a crucial element in these decisions. Future low cost enrichment from GCEP represents a valuable sales incentive in this regard.

a The Department currently holds domestic and foreign contracts with a lifetime sales value in excess of \$100 billion, of which about one-third is foreign. While the termination provisions of these contracts vary, our customers can terminate the contracts at no cost with 3-1/2 to 10 years notice. These existing contracts are vulnerable to termination if the U.S. does not take action to keep our price competitive.

a Without GCEP, U.S. enrichment prices will be perceived by our customers and has already been emphasized by our competitors, Eurodif and Urenco, as being significantly higher in the future. Eurodif, due in part to the weakness of the French franc, presently offers enrichment prices slightly lower than the U.S. price. They stand to realize a considerable market advantage if the potential of GCEP is not realized in the U.S. It is also significant to note that U.S. utilities have expressed a willingness to contract with Eurodif rather than the U.S. if the future economies of U.S. enrichment services do not improve. Though a detailed estimate of potential sales losses is not possible, the continued strength and vitality of a U.S. Government enterprise which produces \$2 to \$3 billion in annual revenues, of which about one-third represents a positive contribution to the U.S. balance of payments position, is a worthwhile consideration. In this regard, the commitment to building GCEP is a major positive force. We strongly disagree with GAO that this balance of payment impact, almost \$1 billion in FY 1983, is insignificant and can, therefore, be ignored. When our nation is in a negative trade balance, all large contributions are important in reducing the deficit.

Enrichment Demand

1 Based upon recent developments, we agree that the year 2000 demand projections
5 contained in our last year's forecast have further eroded. Our most recent preliminary assessment is that our new mid-range forecast by the year 2000 will be closer to the GAO forecast of 217 gigawatts. However, the conclusion that we need GCEP to maintain the commercial viability of U.S. enrichment is valid based upon any responsible demand forecast, including the GAO numbers.

- a The market to be served by DOE in the future will depend, to a very large extent, on actions we take today. We must take positive actions, such as construction of GCEP, to retain our existing contracts and to capture new demand. Failure to construct the most cost efficient technologies available today will result in further reductions in U.S. sales as has been the case in other U.S. industries for their goods and services.

GAO's Economic Analysis

- 16 GAO's analysis of DOE's economic justification of GCEP is incomplete and inaccurate. GAO focused on the DOE economic model (EDIC) used in the 1980 Strategy Study in evaluating DOE's economic justification for GCEP. Other analyses have been performed, as reported in the December 1981 Operating Plan Paper. Comparisons of the unit cost of product and future prices of enrichment services have also been prepared. All of these analyses support DOE's claim that completing GCEP will lower the costs of uranium enrichment and provide assurance that enrichment costs will not escalate rapidly if AIS is not available.
- 15 GAO questions the economic benefits of GCEP by assuming that demand is by far the most critical factor affecting GCEP economics. This is not true. While demand is an important factor, more important considerations are the introduction date and cost of AIS, power cost escalation, general inflation, and GCEP cost.
- 18 In structuring its economic analysis, GAO projected constant dollar electric power cost escalation of 0.4 percent per year through 1990 and 0 percent thereafter. This results in a 1990 rate that is only 3.2 percent higher than today's rate in constant dollars. GAO indicated that these results were consistent with the mid-case electric power price escalation rate in the Energy Information Administration (EIA) 1981 Annual Report to Congress. Tabular data from that report show that EIA is projecting industrial power cost growth in the period 1980 to 1995 ranging from 1.2 to 1.7 percent per year above general inflation. This results in a real increase that is three to four times the GAO figure. Over the last 10 years the cost of power to the uranium enrichment plants has increased an average of 10 percent per year over the general inflation rate.
- 21 Furthermore, GAO has not included in their analysis the impact of all of DOE's power contracts that expire in the early 1990's. The terms and conditions of new power contracts could be less favorable which correspondingly would increase long-term power costs.
- 20 The GAO analysis was also not objective in its treatment of the relative uncertainties of GCEP and the AIS technologies. An analysis which assigns a cost penalty to the proven gas centrifuge technology and no penalty to the less developed AIS technology is not an objective analysis. DOE has recently announced the selection of one of the three competing AIS technologies for large-scale engineering and demonstration. However, there are still substantial scientific and engineering issues that must be resolved before large-scale

deployment of the selected process is possible. The unresolved issues raise uncertainties as to the ultimate date of production deployment and the cost of production. The definitive resolution of these uncertainties will require the design, construction, and operation of the Development Module. It is important to realize that the commercial viability of the AIS process cannot be established until 1990 at the earliest, one year after operation of the Development Module. Therefore, the earliest possible start of construction for a production facility would be in FY 1990 and full scale operation at the end of FY 1995.

- 8 In GAO's economic analysis, they estimate a cost advantage in meeting demands with the GDPs plus AIS capacity but without GCEP. This is the same result as previously indicated by DOE in the 1980 Strategy Study if it were possible to assume complete success of the AIS program. This slight savings disappears quickly if AIS fails to meet the 1995 target commercialization date. The major concern in the DOE enrichment program is that GDP production costs are increasing due to its dependence on electric power. Savings can be realized by replacing it with lower cost capacity, either gas centrifuge, AIS, or a combination of both. Using all of GAO's recommended assumptions, the net present value savings of replacing GDP capacity with GCEP and AIS is \$8.5 billion. If AIS alone is used and available beginning in 1995 to replace GDP capacity, the savings would be \$9.0 billion which is \$0.5 billion better than building GCEP and AIS together. However, just a 1-year slip in AIS availability with no increase in cost eliminates this \$0.5 billion AIS advantage. If AIS slips 5 years, then building GCEP has a \$2.1 billion advantage. To the extent that AIS costs are higher than projected, or power costs escalate at a rate greater than GAO assumed the GCEP economic advantage increases. Even assuming the low GAO demand, similar results would occur.
- 21 DOE must maintain an assurance of adequate production capacity to meet contractual demand. Under our present operating plan, which includes GCEP, we are able to significantly reduce power purchases needed to operate the GDP in the mid-1990s and later. If a decision is made to terminate GCEP and rely on AIS, we would have to sign additional power contracts for the mid-1990's to 2000 period because we cannot base our production planning on AIS until 1990 at the earliest. It is necessary to sign contracts for power about 10 years in advance for the quantities required by the GDPs.
- 21 By 1990, one of two scenarios would result if GCEP were cancelled. If AIS is successful, then DOE must either terminate some of the power contracts and pay capacity charges or delay implementing AIS until the capacity charges can be avoided. Either option is uneconomical. If AIS is unsuccessful, then the GDP would be our only capacity, and, clearly, we would be at a major price disadvantage with our competitors.

9 In our view, to make a case for cancelling GCEP on the basis of cost and schedule projections for a technology that will not demonstrate production readiness until the end of this decade would be unwise.

a We feel that much of GAO's criticism of the computerized model is unfounded. GAO is justified in criticizing the lack of documentation. However, DOE did not "constrain the model." The term "constrain" is simply inappropriate for discussing the two-step procedure which was used to run some of the cases in the October 1980 Uranium Enrichment Strategy Study. GAO's contention that the model does not in one instance reflect economic reality is not valid. Finally, the model's use of an approximation of the year that the feed stockpile is depleted has been shown not to result in any significant bias between alternative cases.

GAO note: We did not evaluate this DOE comment because it is not important to understanding the issue surrounding construction of the gas centrifuge plant. As stated on page 24 of our report, DOE's model is useful for relative comparisons of alternative enrichment technologies.

GCEP Costs

19 We have confidence in our GCEP construction cost estimate. To date, the estimated cost has remained stable with the exception of escalation and costs associated with the revised schedules. The bulk of the technical support and engineering has been completed providing a sound basis for estimating procurement and construction costs. We have bid experience on 90 percent of the construction and procurement packages, other than the centrifuge machines. The centrifuge machine cost is 40 percent of the plant cost. The only estimating difficulty in centrifuge cost is the rotor. The cost associated with the rotor represents less than one-fourth of the total machine cost, or less than 10 percent of the total project cost.

19 The GAO report does not recognize that the current cost estimate does include a contingency of 15 percent for machine costs and 10 percent for the entire project.

Budgetary Impacts

23 GAO does not accurately provide the budgeting impacts of terminating GCEP. Should GCEP be terminated at the end of FY 1982, the budget authority request for FY 1983 for GCEP could be reduced from \$613 to \$350 million. The \$350 million would be needed to pay termination costs for existing GCEP-related contracts. In addition, uranium enrichment revenues would decrease by about \$112 million in 1983 because GCEP costs would be deleted from the cost recovery charge. The net impact on the 1983 budget would be a decrease in the budget authority request of \$151 million.

23 Budget outlays for FY 1983 would actually increase from \$525 million to about \$700 million and thus work contrary to our efforts to balance the FY 1983 budget. This happens from spending the additional \$350 million in budget authority that would be needed plus spending the end of FY 1982 commitments.

- 22 Without GCEP, additional production would have to come from the existing gaseous diffusion plants. The timing of production from diffusion capacity could be earlier than production from GCEP in order to minimize production costs. Accordingly, power budgets could be higher prior to 1988, thus mitigating the impact of reduced GCEP costs. There would also be decreased revenues in the next several years.
- a In summary, DOE believes that GCEP is critical to our efforts to remain competitive in the world marketplace and to provide enrichment services to our existing domestic and foreign customers. The GAO report contains many unsupportable statements and conclusions, an unquestioning projection of the AIS process, and an unrealistic assessment of the impact GCEP has on the international market. Enclosed are additional detailed comments on the GAO report.

Sincerely,


William S. Heffelfinger
Assistant Secretary
Management and Administration

Enclosure

Enclosure

GCEP Costs

- 19 GAO states (page 19) that it increased GCEP estimated costs by 10 percent to recognize historical cost overruns on Federal projects. To date, the GCEP construction has proceeded within cost and schedule objectives and there is good reason to believe that this good record will continue since the plant involves constructing eight process buildings which are essentially identical. One building is almost completed and a major support facility, the Recycle/Assembly Building, is well under construction.
- 19 We have confidence in the GCEP construction cost estimates. To date, the estimated cost has remained stable with the exception of escalation and costs associated with deliberate schedule delays. The bulk of the technical support/engineering has been completed providing a sound basis for estimating procurement and construction costs. We have bid experience on 90 percent of the construction and procurement packages, other than the centrifuge machines.
- 19 While a significant portion of GCEP costs are represented by the centrifuge machines, a significant number of prototype machines have been manufactured and are being tested. Even though production has not reached the mass production phase, the manufacturers have developed and tested essentially all equipment that will be used for mass production. Machine manufacturers are in competition for additional contracts. There has been very active participation from the centrifuge manufacturers in value engineering programs that have already made significant savings in the machine costs. To reduce manufacturing costs that have been highlighted by the Machine Phase I program, a product improvement program is underway. This program will reduce and/or preclude cost growth and improve machine reliability. The centrifuge machine cost is 40 percent of the plant cost. The only estimating difficulty in centrifuge cost is the rotor. The costs associated with the rotor represent less than one-fourth of the total machine cost or less than 10 percent of the total project cost. DOE's current project cost estimate already includes 15 percent contingency for machine costs and a 10 percent contingency in total project cost.
- a Furthermore in regard to centrifuge plant costs, GAO has used the principle of "guilt by association" rather than a detailed analysis of the project cost bases and trends. Comparison of GCEP cost to projects outside of uranium enrichment is not as relevant as comparison to historical costs experienced by DOE in the enrichment field. For example, DOE's cost experience on the Cascade Improvement and Upgrading (CIP/CUP) programs has been very good and actually has underrun the cost estimate. The circumstances surrounding the

GCEP cost are summarized very well in an Engineering News Record article dated April 29, 1982. The article states "Confounding predictions that first-of-a-kind process-plant megaprojects inevitably go awry, the Department of Energy's \$10 billion gas centrifuge uranium enrichment plant, after 3 years of construction, is rising on schedule near Piketon, Ohio, within 1 percent of 1979 estimates. A detailed conceptual design, smart management, liberal design fees, hungry contractors and cooperative unions are combining to prove the pundits wrong."

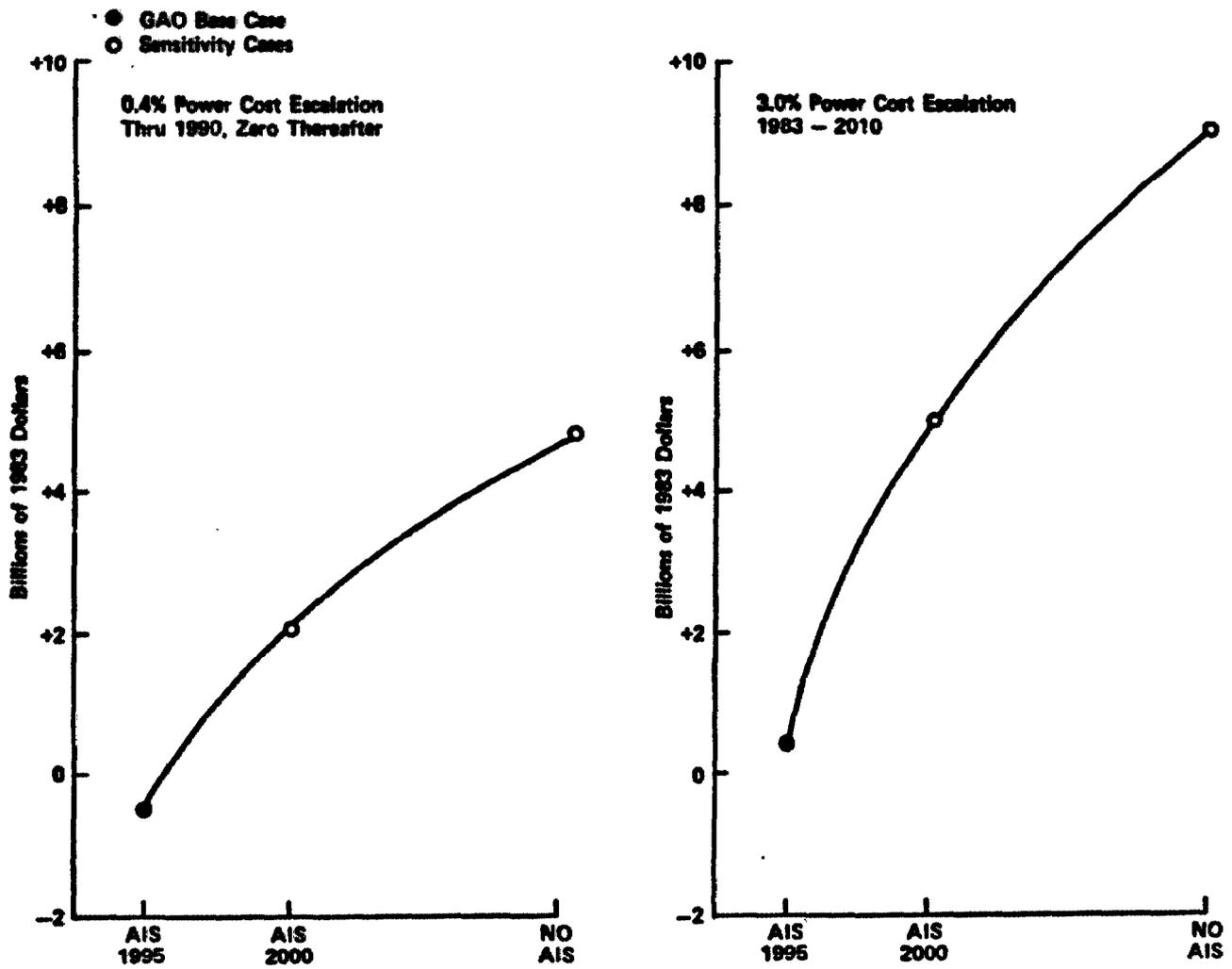
AIS Costs

20 The treatment of uncertainty for the well developed gas centrifuge technology discussed earlier is completely ignored by GAO in assigning costs to the undeveloped AIS processes. While DOE feels that the AIS processes have good potential, DOE recognizes and GAO states (page 17) that there is uncertainty with the AIS and only scientific feasibility has been established. There is a significant risk that AIS might not be available in 1995 or at current projected costs as GAO chose to assume in its analyses. GAO ignored the risk and associated costs of AIS schedule slippage which are very significant. It is also noteworthy that GAO did not apply its "policy" of escalating the AIS estimated costs by 10 percent in recognition of historic overruns. Failure to treat AIS costs on a comparable basis as GCEP costs creates a bias against GCEP.

GAO Economic Analysis

8 DOE, in performing the 1980 Enrichment Strategy Study and in its current analysis, recognized the risks associated with the undeveloped AIS technology. In GAO's economic analysis, they state that at their estimated demand level of 217 GWe, it is slightly cheaper to meet demands with the gaseous diffusion plants (GDP's) and AIS and not build GCEP. This is the same result as previously indicated by DOE in the 1980 Strategy Study. However, in assessing risk DOE recognized that this slight savings disappears quickly if AIS fails to meet the 1995 completion date. The major concern in the DOE enrichment program is that GDP production costs are increasing rapidly and markedly due to its dependence on electric power. Savings can be realized by replacing it with lower-cost capacity, either gas centrifuge, AIS, or a combination of both. Using GAO's recommended assumptions, the net present value savings of replacing GDP capacity with GCEP and AIS is \$8.5 billion. If AIS is available in 1995 at projected very low enrichment prices and is used instead of GCEP to replace GDP capacity, the savings would be \$9.0 billion which is \$0.5 billion better than the combination of GCEP and AIS. However, just a 1-year delay in AIS availability eliminates this apparent \$0.5 billion AIS advantage. If AIS availability is delayed 5 years to CY 2000, the AIS advantage becomes a \$2.1 billion disadvantage, even if AIS costs don't increase. This sensitivity to the AIS availability date is graphically demonstrated in Figure 1. This

Figure 1
GCEP Benefit
(Net Present Value 1983-2010)



sensitivity was one of the major issues in the 1980 Strategy Study and is discussed by GAO in their report (page 17). However, GAO ignored this vital issue in their quantitative analysis.

- a Power costs are also significant risk factors. As shown in Figure 1, a higher power cost escalation of 3.0 percent eliminates the AIS advantage and results in a greater benefit for completing GCEP. The GCEP benefit increases from \$0.4 billion if AIS is on schedule, to a benefit of \$5.0 billion if AIS is delayed 5 years. While DOE believes that 3 percent power cost escalation is on the high side, this comparison demonstrates the sensitivity of the results to this parameter and quantifies the large risk that would be assumed if GCEP is not built. As shown in Figure 1, GAO selected a very biased set of assumptions and presented this "tip of the iceberg" as a basis for making a decision on GCEP. Underlying their analysis is a large matrix of risks that could result in significant costs to the Government and DOE enrichment services customers.

GAO note: We did not evaluate this comment because the 3 percent power cost escalation rate used is, as DOE says, "on the high side."

a Validation of the EDIC Model

Our responses to the alleged errors and deficiencies in the EDIC model are as follows:

1. "DOE failed to adequately document the model." There is some justification for this comment since the only existing documents prior to December 1981 consisted of a User's Manual and a published report by D. E. Hatch and S. A. Levin. However, from December 1981 through April 1982, considerable assistance was provided to GAO including written memoranda and copies of computer outputs of cases from the 1980 Strategy Study.

The only mathematical errors in the article are those caused by typographical errors. These typographical errors in the Hatch and Levin article were pointed out to GAO in a meeting in January 1982. Thus, the comment that "the article is inconsistent and imprecise in its use of mathematical notations" is an unnecessary rebuke of this article.

2. "DOE constrained the model." This apparently refers to the fact that some of the model runs in the 1980 Uranium Enrichment Strategy Study were done in two separate steps. For cases characterized by increasing diffusion plant power levels in the early part of the campaign with subsequent decreasing diffusion power levels as new capacity became available, DOE found that the model had considerable difficulty in obtaining a solution for a 30-year campaign period. To overcome this difficulty, the DOE contractor first made a model run for the initial part of the campaign. These results were then fixed into a second run

which covered the full 30-year period. While not as straightforward as a single step optimization might be, DOE and its contractor believed that the two-step optimization procedure for two sequential time periods provided a valid solution.

Shortly afterward, the DOE contractor developed an improved, more efficient, version of the model which was able to analyze the entire campaign in a single step. Reruns of the 1980 Strategy Study cases with this improved model gave results that were within a fraction of a percent of those obtained in the original work. Most importantly, there were no changes in the relative rankings of any of the cases.

3. "DOE's model does not, in one area, reflect economic reality." This comment refers to the fact that the government feed stockpile is valued at the market price in the year that the government feed stockpile is exhausted and that value is then discounted to the year of actual usage.

DOE and its contractor believe the method of valuing government feed in the model is valid and consistent with principles of economic theory. The government feed stockpile was accumulated as a result of purchases in the early years when the government provided support to a developing uranium mining industry. Since the cost of this stockpile is a sunk cost, the valuation to be placed on the stockpile should be a representation of the fair worth or value of this stockpile. As long as the stockpile exists, the government avoids having the expense of purchasing any feed material. Thus, the value of any feed material extracted from the stockpile and transferred to the cascade is reflected in the cost to the government of an equivalent amount of feed material that must be purchased at some point in the future when the stockpile is exhausted. The present value in the year of consumption of this future cost of feed is the proper method for calculating the value of this stockpile.

In reference to the statement that "As a result, the model uses too much feed and not enough electric power" a series of constrained cases were run by DOE in which upper limits on tails assays were fixed at successively lower values to force the use of more power and less feed. These results were then compared to the corresponding case in which the tails assays are not constrained by an upper limit throughout the campaign. These results showed that more power and less feed results in higher costs than the optimum solution of the original case. This would appear to refute the GAO contention.

4. "The computer incorrectly executed the uranium feed portion of the mathematical model." The model, particularly the version which required the use of the two-step optimization procedure, did have difficulty in estimating the year when the feed stockpile is exhausted for optimization purposes. As a consequence, the estimated year of feed stockpile exhaustion as utilized in the calculation was approximated and could be different than the actual year of feed stockpile exhaustion in the final model result. DOE evaluated the significance of this using the improved current version of the model which more accurately estimates the year of feed stockpile exhaustion as well as a new linear program model which is currently nearing completion which does not need to estimate the year of feed stockpile exhaustion. The results of many calculations have shown that the impact of this approximation is insignificant, modifying results by only a fraction of a percent. Moreover, this approximation was shown to have had no significance in terms of modifying the relative rankings of cases in the 1980 Strategy Study.

GAO note: We did not evaluate DOE's comments on validation of the EDIC model for the reason discussed on page 32.

Balance of Payments

- 25 In their discussion of the benefits to the U.S. balance of payments, GAO once again downplays the positive aspects of the uranium enrichment program. Foreign sales in FY 1980 were \$454 million which GAO dismisses as only being one-tenth of one percent of total U.S. exports in 1980. Continuing to keep current customers and attract new customers is a major DOE goal which will increase the balance of payment benefits. Foreign sales in FY 1982 are estimated to be \$840 million and will approach \$1 billion in FY 1983. We strongly disagree with GAO that this balance of payment impact is insignificant and can, therefore, be ignored. When our nation is in a negative trade balance, all large contributions are important in reducing the deficit. Also, to the extent that domestic utilities purchase foreign SWUs because of price, the U.S. balance of payments position worsens.

Budgetary Impacts

- 12 The report discusses four budget options that could be followed. The first would continue the project on schedule. GAO is correct in stating that an additional \$5.8 billion will be needed to complete the project. However, the report fails to mention that uranium enrichment revenues have been more than sufficient to cover all uranium enrichment appropriation requirements including GCEP over the FY 1982 and FY 1983 period. DOE anticipates that this trend will continue. Therefore, the uranium enrichment program does not require net appropriation, nor does it contribute to the national debt.
- 22 Also, GAO does not address the impact on future budgets if GCEP is not completed and additional GDP power must be purchased in the future. Compared to operating the GDPs alone, the completion of GCEP at a cost of \$5.8 billion will result in future power cost savings of tens of billions (in today's dollars) even if power costs escalate at only 0.4 percent through FY 1990. This is why GCEP is being built -- to relieve the DOE

- 13 uranium enrichment customers of the burden of future power costs. The report is also wrong in stating that GCEP costs will not be recovered until 1989. In fact, \$25 per SWU of the recently announced price is related to recovering GCEP costs, primarily recovering interest costs on construction work in process.
- 23 The second option is terminating GCEP at the end of FY 1982. The budget authority request for FY 1983 for GCEP could be reduced from \$613 to \$350 million. The \$350 million would be needed to pay termination costs for existing GCEP related contracts. In addition, uranium enrichment revenues would decrease by about \$112 million in FY 1983 because GCEP costs would be deleted from the cost recovery charge. The net impact on the overall FY 1983 enrichment budget would be a decrease in budget authority request of only \$151 million. Budget outlays for FY 1983 would actually increase from \$525 to about \$700 million and thus work contrary to our efforts to balance the FY 1983 budget. This results from spending the additional \$350 million in budget authority that would be needed plus spending the end of FY 1982 commitments.
- 22 GAO recognizes that termination of GCEP will require DOE to purchase more electrical power than currently planned in DOE's enrichment operating plan. GAO states that purchases of this additional power would not require appropriations because these costs are recovered through the enrichment services price. This statement is misleading. All enrichment costs are recovered in the enrichment selling price including GCEP costs. In fact, in FY 1983 despite a funding request of about \$600 million for GCEP, the net uranium enrichment budget request is negative by about \$66 million. GAO ignores this reality. DOE projects that enrichment revenues will be adequate to fully offset budgetary requests for the entire enrichment program, including GCEP, in the future. However, as noted earlier, if GCEP is terminated, FY 1983 revenues will decrease by \$112 million, and budget outlays will actually increase by about \$175 million. Future budget requests will be substantially higher than currently planned due to large additional power purchases, and additional loss of market share resulting from the cancellation of GCEP. Thus, it cannot be categorically stated that appropriations will not be required to offset the increased costs of power to the diffusion complex as GAO alleges.
- 21 Over the longer term, DOE must maintain an assurance of adequate production capacity to meet contractual demand. In our present operating plan, which assumes GCEP, we are able to significantly reduce power purchases needed to operate the GDP's in the mid 1990's and later. If a decision is made to terminate GCEP and rely on AIS, given the current status of AIS, we would have to assure an adequate power supply in the 1990's. Thus, we would need to sign power contracts in the near future because of the very long lead times needed for the quantities of power required by the GDP's. This would put DOE in a position of being liable (as we are today) for payment of capacity charges for GDP power if AIS is successful. Of course, if AIS is unsuccessful, then the GDP would be our only capacity and clearly we would be at a major price disadvantage against our competitors.

- a The third option is to complete only the first two process buildings. The DOE statements on the first two budget options on the need for additional appropriations apply as well to this budget option.
- 24 GAO makes two basic mistakes in the unit cost comparisons on page 29. First, they use DOE's full cost of a two building GCEP in 1983 dollars and compare this figure to an average cost of gaseous diffusion production for FY 1981. So GAO penalizes GCEP with 2 years of inflation more than it does to diffusion. It is misleading to compare GCEP costs with an average diffusion cost since diffusion costs increase as diffusion capacity levels increase. The appropriate comparison is to compare GCEP costs with an equivalent amount of diffusion capacity. From a production standpoint, this type of comparison will result in the lowest cost of production.
- 24 The second major mistake GAO makes is to include sunk costs in the comparison. A decision maker can only affect future costs. Therefore, to arrive at a comparison that will result in the lowest cost of production, only incremental cost should be used for comparison. This type of comparison does not ignore the importance of sunk cost; it just recognizes that these costs have already been incurred.
- 24 With making these corrections to the GAO analysis, the GCEP incremental cost in 1983 dollars for the first two buildings is \$114 per SWU. The comparable diffusion cost is \$108 per SWU. When any inflation rate is considered, the unit cost of GCEP becomes significantly less than diffusion by the time GCEP begins production. For example, by 1996 the two building GCEP will cost \$205 per SWU while diffusion will cost \$330 per SWU assuming nine percent inflation. This occurs because all of diffusion costs are subject to escalation, whereas GCEP has low operating costs (which are subject to escalation) and construction costs once spent do not escalate. For the full eight process buildings, the comparison in 1996 at nine percent inflation is \$130 per SWU for GCEP and \$270 per SWU for diffusion.
- 23 The fourth budget option is to slow the GCEP construction schedule. The GAO report accurately points out that any delay in the GCEP schedule will significantly increase the cost to complete GCEP. This would be unwise in that it would reduce the economic benefits of GCEP and delay the realization of those benefits.



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